

AD735701

MISCELLANEOUS PAPER NO. 4-704

BEHAVIOR OF EPOXY-ASPHALT AIRFIELD PAVEMENTS 1963 INSPECTIONS

by

A. H. Joseph



February 1965

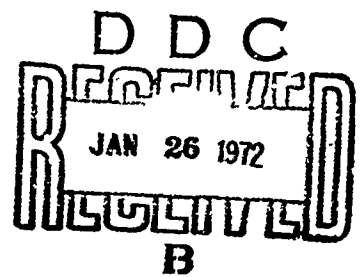
Sponsored by

Office, Chief of Engineers
U. S. Army

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

Conducted by

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi



DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

57

MISCELLANEOUS PAPER NO. 4-704

BEHAVIOR OF EPOXY-ASPHALT AIRFIELD PAVEMENTS 1963 INSPECTIONS

by

A. H. Joseph



February 1965

Sponsored by

Office, Chief of Engineers
U. S. Army

Conducted by

U. S. Army Engineer Waterways Experiment Station
CORPS OF ENGINEERS
Vicksburg, Mississippi

ARMY-MRC VICKSBURG, MISS

Foreword

The epoxy-asphalt pavement inspections reported herein were conducted in 1963 under the investigational program "Maintenance Studies for Airfield Pavements" being carried out by the Waterways Experiment Station for the Military Construction Division, Office, Chief of Engineers.

The investigational program is under the supervision of Mr. W. J. Turnbull, Chief, and Mr. A. A. Maxwell, Assistant Chief, of the Soils Division, Waterways Experiment Station (WES). This report was compiled by Mr. A. H. Joseph of the Soils Division from reports of airfield inspection trips prepared by the WES member of the following inspection teams:

1. Mr. J. O. Izatt, Shell Oil Co.; Mr. O. B. Ray, WES.
2. Mr. D. F. Fink, Shell Oil Co.; Mr. W. H. Larson, WES; and Mr. P. L. Melvill, Office, Chief of Engineers.
3. Mr. N. B. Wilson, Shell Oil Co.; Mr. C. D. Burns, WES.
4. Mr. J. O. Izatt, Shell Oil Co.; Mr. A. H. Joseph and Mr. W. B. Fenwick, WES.

Col. Alex G. Sutton, Jr., was Director of WES during the inspection period and preparation of this report. Mr. J. B. Tiffany was Technical Director.

Contents

	<u>Page</u>
Foreword	iii
Summary	vii
Epoxy-Asphalt Pavement	1
Characteristics	1
Use on airfields	1
Purpose and Scope of Inspections	2
Inspections of Airfields in the Midwest	2
Berry Field, Nashville, Tennessee	2
Wright-Patterson AFB, Ohio	3
Bunker Hill AFB, Indiana	4
Truax Field, Madison, Wisconsin	5
Inspection of Airfields in the West	6
Perrin AFB, Texas	6
Davis-Monthan AFB, Arizona	7
Los Angeles International Airport, Los Angeles, California	8
George AFB, California	8
Stead AFB, Nevada	9
Air National Guard Field, Reno, Nevada	10
Inspection of Airfields in South Atlantic Area	10
Homestead AFB, Florida	10
Patrick AFB, Florida	11
Air National Guard Field, Charlotte, North Carolina	12
Seymour Johnson AFB, North Carolina	13
Langley AFB, Virginia	14
Inspection of Airfields in the Northeast	14
Hancock Field, Syracuse, New York	15
Bradley Field, Hartford, Connecticut	16
Burlington Municipal Airport, Vermont	16

	<u>Page</u>
Loring AFB, Maine	17
Westchester County Airport, New York	18
Discussion of Epoxy-Asphalt Pavement Performance	18
Epoxy-asphalt overlays on portland cement concrete pavement	19
Epoxy-asphalt overlays on bituminous pavements	19
Binder type	20
Climate	20
Conclusions	20
Table 1	
Photographs 1-64	

Summary

This report presents the findings of inspections made in 1963 of epoxy-asphalt pavements at 20 airfields located throughout the United States. It was concluded that:

- a. Epoxy-asphalt pavements are sufficiently resistant to the action of fuel spillage and blast from jet-type aircraft to be used in areas of such spillage and blast.
- b. Thin overlays of epoxy-asphalt pavement are subject to cracking; however, the cracks do not tend to spall or ravel.
- c. The evaluation of the different binder formulations of the epoxy-asphalt is not conclusive; observation of the pavements will continue so that a definite evaluation can be made.
- d. Climate has a direct effect on epoxy-asphalt pavements, i.e. the colder the climate, the greater the tendency for cracking.

BEHAVIOR OF EPOXY-ASPHALT AIRFIELD PAVEMENTS,

1963 INSPECTIONS

Epoxy-Asphalt Pavement

Characteristics

1. Epoxy-asphalt pavement is being considered as a maintenance material for Air Force Base pavements because it is resistant to the action of fuel spillage and jet blast and can be placed with construction equipment used for conventional asphaltic concrete pavements. Epoxy-asphalt pavement mixtures consist of a binder and aggregates. The binder material is a composition of epoxy resins, asphalt, and an additive. The additive performs several functions: it provides compatibility between the epoxy resin and asphalt, and acts as a catalyst and as a plasticizer. The epoxy binder can be introduced in the mixing plant either as a three-component system or as a two-component system; in the latter case, the additive and asphalt are preblended by the binder supplier. The aggregate used in the epoxy pavement mixtures is of a fine gradation with a maximum size of 3/8 in.

2. The epoxy-binder system requires a chemical reaction before final set can occur; this reaction, like many chemical reactions, is affected by temperature. In addition to the original, type I binder, two other epoxy-asphalt binder materials have been formulated (designated types II and III) using softer epoxy resins with different grades of asphalt in an attempt to improve the properties of epoxy-asphalt pavements with respect to cracking in cold climates.

Use on airfields

3. Epoxy-asphalt pavement mixtures have been used in airfield maintenance as thin overlays (3/4 to 1 in. thick) for resurfacing both flexible and rigid pavements. The material has been placed at a number of airfields; however, the total area placed at each airfield has been rather small, the largest job to date being less than 30,000 sq yd. The first epoxy-asphalt pavements were placed at Air Force installations in 1959. Although a guide specification* has been prepared by the Corps of Engineers

* U. S. Army, Office, Chief of Engineers, Guide Specifications for Military Construction; Epoxy-Asphalt Concrete Pavement (Central-Plant Hot Mix), CE-807.24 (1 August 1963).

covering materials and construction on a nonproprietary basis, to date only the Shell Oil Company has furnished binder materials for epoxy-asphalt airfield pavements.

Purpose and Scope of Inspections

4. To observe the behavior of epoxy-asphalt overlay pavements, as affected by traffic, jet fuel spillage and blast, condition of base material on which placed, type of epoxy-asphalt binder used, and climate, teams composed of representatives of the Shell Oil Company and the Waterways Experiment Station (WES) visited 20 airfields in 1963. Four teams made the inspections, each working in one of the following areas of the United States: the Midwest, West, South Atlantic, and Northeast. This report presents pertinent portions of the inspection reports of the WES representatives. The different areas are discussed in the order in which they were visited.

Inspections of Airfields in the Midwest

5. During the period 8-12 April 1963, an inspection team visited airfields at Nashville, Tennessee; Dayton, Ohio; Kokomo, Indiana; and Madison, Wisconsin. These fields are all in locations which experience fairly severe winters; therefore, type II or III binder had been used in all the epoxy-asphalt pavements inspected in this area.

Berry Field, Nashville, Tennessee

6. Description. The experimental epoxy-asphalt pavement at Berry Field was constructed in September 1962, and consists of two parallel strips, each 106 ft wide by 922 ft long.* These strips were placed on a parking apron over areas which had been paved with asphaltic concrete a year previously. Spots in the asphalt pavement which had been damaged by solvent spillage were repaired prior to placement of the overlay. The

* The figures given in the text are taken from the inspection reports and are estimates of the size of the epoxy-asphalt pavement area made by the inspection team, while the figures given in table 1 are the actual measurements.

perimeter of the area to be paved was given a tack coat of epoxy-asphalt binder and the interior areas were given a tack coat of liquid asphalt, RC-2. The overlay is 3/4 in. thick. The pavement contained 8.3 percent type II binder material; the aggregate consisted of 50 to 54 percent river sand, 40 to 44 percent fine crushed limestone, and 6 percent limestone dust filler.

7. Usage. The Tennessee Air National Guard operates from Berry Field. The only planes using the epoxy-asphalt parking apron are C-97's which are propeller-driven planes; hence, they spill very little fuel on the pavement. However, during maintenance a great amount of lubricating oil is spilled, as well as some brake and hydraulic fluids. Apparently little effort is made to minimize spillage or to remove the spilled materials.

8. Condition of epoxy-asphalt pavement. Photographs 1-4 show the epoxy-asphalt pavement at Berry Field. The spillage has resulted in little or no apparent damage to the pavements. Examination of the surface did not reveal any softening. There was a small amount of shrinkage cracking in the longitudinal joints, which was most prevalent in the third joint from the south edge and the second joint from the north edge of each panel area. In spite of the spillage and the limited shrinkage cracking, the pavement as a whole was in excellent condition. The surface texture was good, and the joints were exceptionally smooth and well formed. Only time will tell whether the spilled fluids will enter the shrinkage cracks and damage the underlying asphaltic concrete. At the time of the inspection, oil appeared to be seeping into only one crack.

Wright-Patterson AFB, Ohio

9. Description. In October 1962, two sections on the aircraft parking apron, area "C," at Wright-Patterson AFB were overlaid with epoxy-asphalt concrete. On one section, which was estimated to be 165 by 87.5 ft, a 1-in.-thick strip approximately 25 by 87.5 ft was placed on a new portland cement concrete base, while on the remaining 140 ft of the section a 1-in.-thick strip was placed over a new 1-1/2-in.-thick, tar concrete leveling course overlying a portland cement concrete base. Before the section was overlaid, a tack coat of epoxy asphalt was placed over the new concrete base and around the perimeter of the tar concrete leveling

course; the interior of the tar concrete was not given a tack coat. As part of the initial construction, joints were sawed in the epoxy asphalt placed directly over the new portland cement concrete; these joints corresponded to those in the underlying concrete and were filled with joint sealer meeting the requirements of Federal Specification SS-S-164. The second section overlaid with epoxy asphalt consisted of a strip approximately 15 by 175 ft which had been laid as a ramp connecting a taxiway with the parking area. It was overlaid with a 1-in.-thick, compacted epoxy-asphalt pavement placed partly over old portland cement concrete and partly over a tar concrete leveling course. The aggregate used on both sections consisted of 22 percent fine sand produced from crushed gravel, 30 percent crushed fines, and 48 percent natural sand; the binder contained 8 percent type II epoxy resin.

10. Usage. Both the large and small sections had been subjected to traffic from various types of aircraft but no evidence of fuel spillage or blast was apparent.

11. Condition of epoxy-asphalt pavement. Photographs 5-8 show the epoxy-asphalt pavement at Wright-Patterson AFB. In the first section, the sawed and filled joints in the strip overlying the new concrete were messy, indicating poor workmanship in filling the joints. There was no appreciable secondary cracking in this strip. In the portion overlying the tar concrete leveling course, the large expansion joints and some of the smaller contraction joints in the underlying portland cement concrete had reflected through the epoxy-asphalt overlay to the surface. The cracks ranged in width from fine hairlines to about 1/8 in.; in general, they followed the underlying joints, but in some instances meandered a few inches from straight lines, with little or no secondary cracking or raveling along the joints. In the second section, at the meet line of the taxiway and ramp, evidence of poor workmanship was manifested by rough and segregated areas. This section also had reflection cracks from the underlying concrete, but was otherwise intact.

Bunker Hill AFB, Indiana

12. Description. Two epoxy-asphalt overlays were placed in May 1962 at Bunker Hill AFB. One overlay, containing 555 sq yd, was placed on a portland cement concrete apron located near the base administration

building. The concrete was pockmarked from "pop outs," but not otherwise distressed. It was cleaned by brooming and given a tack coat of epoxy-asphalt binder before being overlaid. The other overlay was placed on a 1444-sq-yd area over a new, 1-1/2-in.-thick asphalt leveling course which had been placed over an old asphaltic pavement which had been damaged by fuel spillage. Both overlays were constructed using type III binder.

13. Usage. The overlay over the rigid pavement has been subjected to only light traffic and little, if any, fuel spillage. The epoxy-asphalt overlay on the flexible pavement is used as a parking apron for fuel trucks, as shown in photograph 9, and is subjected to considerable spillage of fuel and lubricating oil.

14. Condition of epoxy-asphalt pavements. The overlay on rigid pavement has the usual reflection cracks over joints in the pavement (photograph 10). There were also some very peculiar cracks that were not observed elsewhere. These were very fine cracks in the form of circles ranging from 6 to 10 in. in diameter (photograph 11). One of these circles was sawed out in an attempt to discover the cause of the cracks, but the only possible clues were the lack of bond within the circle and a slight irregularity in the rigid pavement surface near the center of the circle (photograph 12). This lack of bond may indicate that a blister formed and moisture collected under the overlay during the curing process. Excepting these circles, the overlay was in excellent condition. The construction joints were especially good. The overlay on the flexible pavement was also in good condition. There was no apparent damage from either traffic or fuel spillage. However, one pronounced crack extended about two-thirds of the way across the adjacent flexible apron and completely across the epoxy-asphalt overlay. No explanation could be found for this crack and it could not be determined whether the crack started in the overlay and progressed into the asphaltic concrete or vice versa.

Truax Field, Madison, Wisconsin

15. Description. In September 1962 a total of 12,100 sq yd of epoxy-asphalt overlay was placed in 3/4-in. thicknesses on two parallel strips, 60 ft wide and 100 ft long, of a parking area. The pavement was placed over portland cement concrete which had previously been overlaid with a leveling course of asphaltic concrete varying in thickness from

1 to 2-1/2 in. The binder used was type II and the aggregate was composed of 29 percent fine gravel, 53 percent coarse sand, 13 percent fine sand, and 5 percent limestone filler.

16. Usage. The pavement has been subjected to considerable parking traffic, mostly by F-89 jets with gross weights up to 44,000 lb, using 46-by 9-in. tires inflated to 200 psi (photograph 13). The pavement had also been subjected to very profuse fuel spillage (photographs 15 and 16). An area about 4 to 6 ft in diameter where hydraulic fluid had been spilled on the pavement was observed.

17. Condition of epoxy-asphalt pavement. All sections of the epoxy-asphalt overlay pavement attested to excellent workmanship. There was no evidence of checks, tears, or segregated areas. Reflection cracks from the joints in the rigid pavement existed over almost the entire overlay (photograph 14). No detrimental effects from the fuel spillage were observed on the overlay, although in places where fuel had flowed from the epoxy asphalt onto the normal asphalt concrete, some softening of the asphalt concrete had occurred. Slight softening of the epoxy-asphalt overlay had occurred in the area of hydraulic-fluid spillage.

Inspection of Airfields in the West

18. During the period 22-26 April 1963, an inspection team visited airfields at Sherman, Texas; Tucson, Arizona; Los Angeles and Victorville, California; and Reno, Nevada.

Perrin AFB, Texas

19. Description. The epoxy-asphalt pavement at Perrin AFB consisted of 10,500 sq yd of overlay 3/4 to 1 in. thick placed over an asphalt-surfaced parking area for refueling trucks. The overlay was constructed in September 1962 using type II binder. The then-existing surface of the parking area was in generally poor condition. Only extremely unsatisfactory portions were repaired before the epoxy-asphalt overlay was placed; therefore, there were extensive areas of fuel-saturated pavement and areas exhibiting deterioration from other causes. Photograph 17, taken at one edge of the overlay, shows the condition of the original pavement.

20. Usage. The epoxy-asphalt concrete overlay is in an area used

by fuel trucks, and spillage of fuel and oil occurs continually. Photograph 20 shows a typical large spillage area.

21. Condition of epoxy-asphalt pavement. In general, the epoxy asphalt showed little or no damage from the spillage where the underlying pavement was firm enough to provide support and prevent cracking of the overlay. Some areas of surface disintegration were noted, as shown in photograph 21. It appeared that such damage was caused by the heavily saturated underlying pavement. Cracking was observed in some areas. These cracks were usually parallel to the paving lanes, as shown in photograph 18. Most of the surface was smooth, but some placement irregularities had resulted in varied textures in a few areas (photograph 19).

Davis-Monthan AFB, Arizona

22. Description. The epoxy-asphalt pavement at Davis-Monthan consisted of an overlay of 28,000 sq yd about 3/4 in. thick on taxiway 15 and the warm-up apron leading to the north end of runway 6. Most of the overlay was on 3 in. of asphaltic concrete, but it also extended over part of a portland cement concrete keel at the intersection of taxiways 14 and 15. The overlay was constructed in May 1961. About 9.5 percent type I binder was used.

23. Usage. This pavement is used as a warm-up area for B-47 aircraft, usage being concentrated at three of four stations. Thus the pavement is subjected to blast from engines and fuel spillage.

24. Condition of epoxy-asphalt pavement. A condition survey made by the Base Civil Engineer in June 1962 when the overlay was one year old showed that considerable cracking had occurred. The cracking was attributed to overloading, shrinkage, and reflection from cracks in underlying pavements. Some lack of bond with the underlying pavement was also noted. The condition survey recorded the crack pattern, and included photographs illustrating the various types of cracks, sealing efforts, and performance of repair patches. The condition survey further showed no evidence of damage from blast or fuel spillage.

25. The 1963 inspection indicated that the condition of the overlay had changed little during the second year of service from that reported in the survey made in 1962. Areas of considerable size still existed in which no cracking had occurred, as shown in photograph 22. Sealing of cracks

using several materials containing epoxy asphalt or straight asphalt had been unsuccessful, as shown in photograph 23. The assumption that some of the cracking was reflection is substantiated by photograph 24, which shows a crack in the shoulder paving continuing into the epoxy-asphalt overlay. Other cracks definitely appeared to be due to shrinkage, as shown in photograph 25, and there appeared to be horizontal movement in some areas where turning of aircraft occurs. This could only happen where the overlay and underlying pavement are not bonded. Reflection cracks were still the only type of cracks noticeable in the overlay over the portland cement concrete keel. No damage from jet blast or fuel spillage was found.

Los Angeles International
Airport, Los Angeles, California

26. Description. Two portions of an asphaltic concrete apron in front of the Pan American Airways maintenance hangar were overlaid with a total of 3000 sq yd of epoxy asphalt by the Shell Oil Company in July 1959, using type I binder. The existing asphaltic concrete was in good condition prior to the overlay.

27. Usage. This area is used for maintenance of commercial airplanes. It is subjected to considerable fuel and lubrication oil spillage as well as traffic from the aircraft.

28. Condition of epoxy-asphalt pavement. This early experimental installation is performing in a near-perfect manner. Some areas of lubricating oil spillage were noted. These areas had been blotted with sand, and when examined, the pavement under the spillage showed no signs of deterioration. Several factors contributed to the excellent performance of the epoxy asphalt in this installation. The overlay was placed over a pavement in good condition, so adequate structural strength was provided. The two epoxy-asphalt areas are relatively small, which minimizes the tendency toward cracking from shrinkage. Tendency toward cracking is minimized further by the mild climate and minor temperature fluctuations of the Los Angeles area.

George AFB, California

29. Description. A 1-in.-thick epoxy-asphalt pavement was placed in October 1962 on three areas at the runway ends. A total of 10,950 sq yd of overlay was placed. In two areas the epoxy-asphalt concrete was placed

over a 2-in.-thick, new asphaltic concrete overlay on portland cement, and in the third area the overlay was placed directly on the portland cement concrete. The aggregate consisted of 45 percent unwashed sand, 45 percent washed sand, and 10 percent 5/16-in. crushed stone. The binder contained 8.5 percent type II epoxy resin.

30. Usage. Aircraft operating on the runway are mostly fighter planes of the F-100 series. The overlays are in landing areas of the runways and are subjected to very little fuel spillage; however, they are subjected to blast from the aircraft.

31. Condition of epoxy-asphalt pavement. Reflection cracking had occurred over the portland cement concrete joints on the northeast end of the runway. Occasional small shrinkage cracking, as can be seen in photographs 26 and 27, had also developed. Attempts at filling the cracks with an epoxy-asphalt emulsion, as seen in photograph 28, had not been successful. Reflection cracking also occurred on the southwest end of the runway, as shown in photographs 29 and 30. An area free of cracking is shown in photograph 31.

32. Several blisters were observed in the 1500-sq-yd area laid directly over new portland cement concrete. Some of the blisters had been punctured immediately after paving was completed. At the time of this survey, one puncture was visible and contained water, as shown in photograph 32.

Stead AFB, Nevada

33. Description. A 3/4-in.-thick overlay of epoxy asphalt was placed over a 3400-sq-yd area of asphaltic concrete apron in October 1962. The asphaltic concrete was about 2 in. thick and was placed directly on the subgrade. The epoxy-asphalt overlay was constructed of 25 percent 1/4-in. maximum size crushed stone, 68 percent sand, and 7 percent dolomite filler. Type II epoxy resin was used in the proportion of about 8 percent by weight of total binder.

34. Usage. The overlay was designed to be used as a helicopter landing pad but had not been used prior to the inspection because it was thought that the weather had been too cold for the resin to cure properly. At the time of the inspection, however, the pavement appeared to be entirely cured.

35. Condition of epoxy-asphalt pavement. There were a number of reflection cracks at joints in the old pavement and a few random cracks which appeared to be from shrinkage. The presence of these cracks was another reason that the pavement had remained closed to traffic, as the Base Civil Engineer wanted to repair them while the pavement was still clean and the cracks were free from debris which would be worked into them by traffic. The epoxy-asphalt overlay is shown in photographs 33-36.

Air National Guard
Field, Reno, Nevada

36. Description. A 3/4-in.-thick epoxy-asphalt pavement was placed over approximately 10,000 sq yd of a 3/4-in.-thick asphaltic concrete maintenance apron and ramp in August 1962. The mix design for the overlay consisted of a blend of 3/8-in. maximum size stone chips, concrete sand, and dolomite filler. The binder contained 7.4 percent type III epoxy resin.

37. Usage. The overlay was being used for parking and maintenance of RB-59 aircraft. Some solvents and oil were spilled on the overlay.

38. Condition of epoxy-asphalt pavement. In general the overlay was performing quite satisfactorily. There was no evidence of damage from solvents spilled on the pavement and the major portion of the overlay was free from any defects, as shown in photographs 37 and 38. However, there were some random shrinkage cracks, as shown in photographs 39 and 40. A shrinkage crack generally paralleling a longitudinal construction joint is shown in photograph 41.

Inspection of Airfields in South Atlantic Area

39. During the period 30 April-3 May, an inspection team visited airfields at Homestead and Cocoa Beach, Florida; Charlotte and Goldsboro, North Carolina; and Hampton, Virginia.

Homestead AFB, Florida

40. Description. An epoxy-asphalt pavement was placed over a small portion (2100 sq yd) of the tar-rubber apron at Homestead AFB in the fall of 1959. The paving mixture contained type I binder and 1/4-in. maximum size Florida limerock aggregate. The overlay was approximately 3/4 in.

thick. The tar-rubber pavement was in good condition prior to the overlay, except for numerous shrinkage cracks varying in width from hairline to about 1/4 in. The area overlain received a tack coat of RC-asphalt material.

41. Usage. This pavement was subjected to fuel-spillage and jet-blast tests after about a 30-day curing period, with no detrimental effects. A description of the construction, and fuel-spillage and blast tests is given in WES Miscellaneous Paper No. 4-388, Evaluation Tests of Epon-Asphalt Pavement, dated April 1960. Since the initial fuel-spillage and blast tests, the epoxy-asphalt overlay has been used as a maintenance pad for jet aircraft. The overlay pavement has been subjected to periodic concentrated blast from jet aircraft.

42. Condition of epoxy-asphalt pavement. In February 1961 one corner of the overlay pavement, about 6 by 4 ft, was blasted off by the outboard motor of a B-47 aircraft which was parked off the overlay and blasted into a free edge of the pavement. This caused the asphalt tack coat to melt which resulted in loss of bond at the interface of the tar-rubber pavement and the epoxy-asphalt overlay. A description of this blast damage is given in a Memorandum for Record by Mr. C. D. Burns, WES, subject, "Inspection of Epon Overlay Test Pavement at Homestead AFB, Fla., 31 March 1960." During November 1960 another area of the epoxy overlay, approximately 15 by 40 ft, was displaced by blast from a B-47 aircraft. This area was later repaired with asphaltic concrete. There has been no apparent blast damage to the remainder of the overlay since that date. A considerable amount of fuel spillage has occurred on the epoxy overlay, but apparently has not damaged the pavement except for a slight softening of areas where the surface had been pitted by jet blast. No shrinkage or reflection cracks were noted in the epoxy-asphalt overlay.

Patrick AFB, Florida

43. Description. During October 1961 a total of 11,000 sq yd of 3/4-in. epoxy-asphalt pavement was placed over a new asphalt-concrete binder course on each end of the primary runway. Type I binder, Florida limerock, and a local sand were used in the pavement. Details of the design and construction of the pavement are given in WES Miscellaneous Paper No. 4-466, Construction of Epoxy-Asphalt Concrete Pavement,

Patrick Air Force Base, Florida, dated January 1962.

44. Usage. This epoxy-asphalt pavement has been subjected to a high intensity of usage by jet-fighter and cargo aircraft as well as fuel spillage and blast.

45. Condition of epoxy-asphalt pavement. The pavement was in excellent condition with no defects except one hairline crack at a cold transverse joint across one 10-ft-wide paving lane.

Air National Guard Field,
Charlotte, North Carolina

46. Description. An epoxy-asphalt overlay, approximately 5/8 in. thick, was placed on an asphalt parking apron at the Air National Guard Field, Charlotte, North Carolina. The construction history of the overlay pavement is as follows:

<u>Construction Date</u>	<u>Binder Used</u>		<u>Overlay Area sq yd</u>
	<u>Type</u>	<u>Percent</u>	
October 1960	I	8.0	1400
October 1960	II	8.0	1400
August 1962	II	8.0	900

The paving aggregate consisted of 3/8-in. maximum size limestone chips, natural sand, and fly ash, with about 6 percent passing a 200-mesh screen.

47. Usage. The pavement has been used for parking and maintenance of jet fighters and propeller-type cargo aircraft. It has been subjected to a considerable amount of spillage of various types of solvents, but there was little or no evidence of jet blast.

48. Condition of epoxy-asphalt pavement. The only defect noted in the overlay was cracking. There were random shrinkage cracks throughout the pavements containing both type I and II binders that were placed in October 1960. The cracking appeared to be slightly more severe in the mix containing type I binder than in that containing type II binder. These cracks were mostly very narrow, and there was no evidence of fuel seeping through the cracks to the underlying asphaltic concrete. Indications are that cracking started within the first year after construction and has progressed with time. The new overlay placed in 1962 with type II binder shows only two or three minor shrinkage cracks.

Seymour Johnson AFB, North Carolina

49. Description. During the fall of 1962 a total of 14,500 sq yd of 3/4-in.-thick epoxy-asphalt pavement was placed over a portland cement concrete parking apron at Seymour Johnson AFB. Type II binder was used in the pavement. An asphaltic concrete leveling course, varying from a featheredge to 13 in. in thickness, was used over a portion of the apron, and the epoxy asphalt was laid directly over the portland cement concrete on the remaining portion. An epoxy-asphalt tack coat was used around the perimeter of the overlay and along the concrete joints in a portion of the apron. An asphalt tack coat was used for the remainder of the area.

50. Usage. At the time of the inspection, the pavement was being used primarily as a storage area for jet aircraft wing tanks and had received very little aircraft traffic. A few areas were stained from fuel spillage, but no damage to the pavement had resulted. There was no evidence that the pavement had been subjected to jet blast.

51. Condition of epoxy-asphalt pavement. The only defects in the pavement were reflection cracks from joints in the underlying portland cement concrete. It was estimated that about 30 percent of the expansion joints in the portland cement concrete have reflected through the overlay. A number of reflection cracks developed within two weeks after the overlay was placed. The reflection cracks had developed through approximately 6 to 7 in. of the asphaltic concrete and 1 in. of epoxy asphalt. No reflection cracks were noted where the total overlay thickness was more than 8 in.

52. Maintenance. Some of the cracks were routed and sealed with joint-sealer material during the spring of 1963, as shown in photograph 42. Four different types of joint sealers were used, two cold-applied and two hot-applied. The hot-applied sealers were SS-164 and SS-167. Both of these sealers appeared to be properly bonded to the pavement, and the joints were sealed at the time of inspection. The cold-applied sealers (SS-170 and SS-200A) did not adhere to the epoxy asphalt, and were considered unsatisfactory. Prior to the inspection, the Shell Oil Company had sent two 5-gal cans of a rubberized-tar emulsion to Seymour Johnson AFB for experiments in sealing the reflection cracks. Several cracks were

sealed with this material during the inspection on 1 May 1963. The crack shown in the lower right of photograph 44 was sealed by squeegeeing the emulsion into the crack. The crack on the left of the photograph was sealed by diluting the emulsion with water and pouring it into the crack. The emulsion broke quite rapidly and shrunk down in the crack. The base personnel were planning to refill this crack the following day and also to do further experimenting in filling the cracks. A close-up of the emulsion squeegeed into the crack is shown in photograph 43.

Langley AFB, Virginia

53. Description. A small test pad consisting of only 365 sq yd of 3/4-in. epoxy-asphalt pavement was placed over a portland cement concrete parking apron at Langley AFB during 14-19 June 1962. Type II binder was used in the pavement. The concrete pavement was 15 to 20 years old and was badly broken and spalled prior to the overlay. All loose spalled material was removed, the holes were patched with asphaltic concrete, and the concrete was given a tack coat of epoxy-asphalt binder material prior to placing the epoxy-asphalt concrete overlay.

54. Usage. After the initial 30-day curing period, one jet-fighter aircraft, dripping fuel almost continuously, had been parked on the overlay pavement. Due to the small area, only one plane at a time can be parked on the pad.

55. Condition of epoxy-asphalt pavement. The fuel spillage had stained the pavement, as shown in photograph 45, but had not caused any apparent detrimental effects. No softening or spalling of the pavement had occurred (photograph 46). Although there were some reflection cracks, the pavement was considered to be performing quite satisfactorily.

Inspection of Airfields in the Northeast

56. During the period 27-31 May 1963, an inspection team visited airfields at Syracuse, New York; Hartford, Connecticut; Burlington, Vermont; Limestone, Maine; and Westchester County, New York. This area of the United States experiences severe winters. Two of the epoxy-asphalt pavements inspected contained type I binder since they were constructed in 1959 before development of the other types of binders. The epoxy-asphalt

pavements at the other three fields, constructed in 1961 and 1962, contained type II binder.

Hancock Field, Syracuse, New York

57. Description. The epoxy-asphalt pavement at Hancock Field consists of two 60- by 600-ft areas, 3/4 in. thick, located on the Air National Guard parking area. The pavement was constructed in August 1962, using 8.4 percent by weight of type II binder material. The aggregates used in the mix were primarily limestone with 5 to 7 percent by weight passing the No. 200 screen. The epoxy-asphalt pavement was placed on an existing asphaltic concrete pavement that was in rather poor condition. An RC-2 cutback asphalt was used as a tack coat over the entire area at a rate of 0.05 to 0.10 gal per sq yd. During construction of the pavement, a certain amount of difficulty was experienced as a result of the contractor's adhering to the time schedule, which caused him to produce the mix faster than it could be placed. Consequently, the mix was held too long before placement. One truckload of mixture had to be thrown away, and from the surface appearance of the pavement, some material that was placed was unsatisfactory. This was obvious from checks, tears, and generally ragged surface conditions in a portion of the epoxy-asphalt pavement placed on the south side of the apron.

58. Usage. Although the epoxy-asphalt pavement was being used by F-86 type aircraft, at the time of this inspection no aircraft were parked on the pavement. However, there was evidence in the form of fuel spillage stains that the pavement had been used.

59. Condition of epoxy-asphalt pavement. Generally speaking, the pavement was in satisfactory condition except for some cracking. The cracking was primarily of two types: (a) reflection cracks from openings in the underlying asphaltic concrete pavement, and (b) open construction joints. One joint was open for the entire 600-ft length of the north pad but no transverse cracks were evident. The south pad contained more cracks, which were not restricted to the joints; some cracks in the pad appeared to be reflection cracks. Typical cracks are shown in photographs 47 and 48. In addition, cracks extended outward from the corners of a drop-inlet drain located in the pavement sections (photograph 49). The pavement had been subjected to fuel spillage (photograph 50), but showed no distress

as a result of the spillage. No sign of blast damage was observed.

Bradley Field, Hartford, Connecticut

60. Description. The epoxy-asphalt pavement at Bradley Field consisted of an area of 7000 sq yd, 1/2 in. thick, located on the southwest end of the main runway. The epoxy pavement was placed over an existing asphaltic concrete pavement as protection from jet-fighter aircraft blasts. The pavement was constructed in October 1959 using 8.3 percent by weight of type I binder material.

61. Usage. The pavement had been subjected to traffic of commercial aircraft, including the large jet type, and the F-100 jet fighters used by the Air National Guard.

62. Condition of epoxy-asphalt pavement. Photograph 51 shows the general condition of the pavement. The pavement began cracking during the first year after construction. An effort was made to seal the cracks with an epoxy crack filler, but the crack filler did not perform well. The pavement continued to crack, and at the time of inspection, a number of the cracks were as much as 1/2 in. wide. There was evidence of spalling along one crack (photograph 52); this has not been observed in other epoxy-asphalt pavements. Two types of cracks were observed in the pavement: (a) reflection cracks from cracks in the underlying asphaltic concrete (photograph 53), and (b) the opening of construction joints (photograph 54). The pavement appeared to be performing satisfactorily from the aspect of blast effects; no sign of erosion or blast damage was found. This epoxy-asphalt pavement was serving the purpose for which it was intended; i.e., it was preventing the blast from jet fighters from burning the runway end. However, the pavement was rather badly cracked and would not be satisfactory if subjected to fuel spillage.

Burlington Municipal Airport, Vermont

63. Description. The epoxy-asphalt pavement at Burlington Municipal Airport consisted of 23,000 sq yd at four locations (one large, three small areas) on the parking and maintenance aprons used by the Air National Guard. The pavement was 3/4 in. thick and was placed over an asphaltic concrete pavement. It was constructed in 1962 using 8.3 percent by weight of type II binder material. The aggregates in the mix were composed of 70 percent crushed fines and 30 percent natural sand. From all indications,

the contractor did an excellent job in the construction of this pavement. No surface blemishes were found, and in many instances it was difficult to detect the construction joints.

64. Usage. The epoxy-asphalt pavement was being subjected to traffic from F-89 aircraft. Portions of the pavement are used for parking and for performing maintenance.

65. Condition of epoxy-asphalt pavement. The pavement was in satisfactory condition except that a number of cracks were developing. Each of the four areas showed some cracking; however, the three smaller areas showed more cracking than the larger area. The epoxy-asphalt pavement was being subjected to rather severe spillage on the maintenance areas which, at the time of inspection, was not affecting the pavement. At the junction of the epoxy-asphalt and portland cement concrete the joint had opened and fuel had entered. Photographs 55 through 60 show the condition of the epoxy-asphalt pavement.

Loring AFB, Maine

66. Description. The epoxy-asphalt pavement placed at Loring AFB consisted of 983 sq yd, 3/4 in. thick, on four locations of the existing asphaltic concrete shoulder pavements. The pavement was placed in August 1961 using 8.5 percent by weight of type II binder material. The purpose of the pavement was to provide blast protection for the shoulder pavements behind the B-52 and KC-135 parking stands. An epoxy-asphalt tack coat was used to bond the pavement to the existing asphaltic concrete. Some difficulty was experienced in the construction of the epoxy-asphalt pavement due to the contractor's inexperience with the material. However, as work progressed to the last two pads, good workmanship was obtained.

67. Usage. Even though the epoxy-asphalt pavement was constructed to provide blast protection for the shoulder pavement behind B-52 and KC-135 parking stands, it was evident that aircraft were actually being placed on portions of the epoxy-asphalt pavement.

68. Condition of epoxy-asphalt pavement. The epoxy-asphalt pavement was rather severely cracked on the two pads that were available for inspection (photograph 61). Alert aircraft were parked on the other two pads and they could not be inspected. The areas inspected showed no appreciable damage from blast and, although signs of fuel stains were

present, the pavement was not being affected by the fuel. On a small area where the epoxy-asphalt pavement joined the parking stand, the blast from the outboard engine of a B-52 had gotten under the pavement and blown away a small portion (photograph 62).

Westchester County Airport, New York

69. Description. The epoxy-asphalt pavement at Westchester County Airport consisted of 8500 sq yd, 1/2 in. thick, placed over four areas on an existing asphaltic concrete parking apron used by the Air National Guard. The pavement was constructed in October 1959 using 8.3 percent by weight of type I binder material. The aggregates in the mixture were crushed fines and natural sand. Poor construction practices resulted in an inadequate pavement. This pavement was placed too late in the construction season (October) for best results; also, the pavement had to be placed at night so that the haul trucks could avoid the traffic along the congested 28-mile haul route. The long haul made it difficult to get the mix to the laydown area within the 40-minute pot life of the mixture. As a result of these factors, a poor job of placing the mix was evident from surface tears, extensive cracking, and other blemishes.

70. Usage. The pavement was being subjected to intensive use as maintenance areas for KB-97 aircraft. Large quantities of gasoline, motor oil, and other products used in maintaining aircraft were being spilled on the pavement.

71. Condition of epoxy-asphalt pavement. The epoxy-asphalt pavement at Westchester County Airport had cracked more extensively than any other epoxy-asphalt pavement observed. It is possible that the thinness of the pavement (1/2 in. thick) and the poor construction procedures contributed to this extensive cracking. Photographs 63 and 64 show the type of cracking that has occurred.

Discussion of Epoxy-Asphalt Pavement Performance

72. Pertinent data on and observations of the performance of epoxy-asphalt pavement as a maintenance material are summarized in table 1. This table lists the agency responsible for the design and construction supervision, and gives an appraisal of how well the construction was

carried out. In addition, a performance rating is shown for the pavements, based both on observations and on discussions with installation engineers at the airfields. The performance of the epoxy-asphalt pavements, as affected by type of material on which they were placed (bituminous or portland cement concrete pavements), type binder used, and climate, is discussed in the following paragraphs.

Epoxy-asphalt overlays on
portland cement concrete pavement

73. All of the epoxy-asphalt pavements placed on portland cement concrete pavements have reflected the cracks from the underlying pavement; however, no cracks have occurred other than the reflection cracks. Little or no raveling of the pavement has occurred along these reflection cracks. There have been no complaints as a result of these cracks, and other than their poor appearance, the pavements are considered satisfactory.

74. Fuel leakage into the reflection cracks does not appear to be adversely affecting the epoxy pavement. Little or no spalling or sloughing of the cracks in the epoxy pavement was observed. In the isolated instances of damage to an epoxy pavement from fuel spillages, the damage was always found in areas where the pavement surface had an open texture and the fuel and oils had collected in pools.

75. Damage from jet blast was minor, and in most instances it had occurred around the perimeter of the epoxy pavement where blast had gotten under the pavement and eroded small areas. The total damage to the epoxy pavements from blast and spillage was so minor that for practical purposes the pavements can be considered to be performing satisfactorily (satisfactory for intended use) in areas of blast and fuel spillage.

Epoxy-asphalt overlays
on bituminous pavements

76. The overlays of epoxy-asphalt pavements placed over bituminous pavements have in general performed satisfactorily except for cracking. Three of the epoxy pavements placed over bituminous pavements showed no cracking. However, this is a result of their geographical location since all three are in warm, mild climates (Homestead and Patrick Air Force Bases in Florida and Los Angeles International Airport). The cracking of the epoxy pavement over bituminous pavement was of two types: random

shrinkage, and reflection. At a few locations where the epoxy-asphalt pavement had been placed over a weak foundation, pavement failure had occurred. As in the case of the epoxy-asphalt pavements placed over the rigid pavements, little if any damage was found as a result of fuel spillage or blast.

Binder type

77. The evaluation of the epoxy-asphalt pavements based on binder type is rather difficult due to the limited data available for making a direct comparison of one type with the others. An epoxy-asphalt pavement placed on an apron at a Charlotte, North Carolina, airfield in 1960 afforded the best comparison since half of the pavement contained type I binder and the other half type II binder. The inspection report indicates that slightly more cracking was found in the pavement containing type I binder than in that containing type II binder.

78. Two pavements were inspected that contained type III binder, and both showed a limited amount of cracking.

79. As previously pointed out, the only pavements in which no cracking was found were in warm, mild climates. All three of these pavements contained type I binder; however, in the colder climates, all pavements constructed using type I binder material had cracked.

80. Although the types II and III binder materials were formulated in an effort to provide a material that would not crack in cold climates, it is too soon to state definitely whether these formulations are more resistant to cracking. The majority of the pavements containing these two binder formulations were constructed in the latter part of 1962 and were less than one year old at the time of these inspections. As these pavements become older, an evaluation based on binder type can be made.

Climate

81. The epoxy-asphalt pavements are definitely affected by climate. The pavements placed in areas where the winters are severe showed increase in both intensity and size of cracks over pavements in mild, warm climates.

Conclusions

82. Epoxy-asphalt pavements are sufficiently resistant to the action

of fuel spillage and blast from jet-type aircraft to be used in areas of fuel spillage and blast.

83. Thin overlays of epoxy-phalt pavements are subject to cracking; however, the cracks do not tend to spall or ravel. The problem of cracking will have to be observed for another year or longer in order to determine how serious it will become. Provided the random shrinkage cracking can be controlled, epoxy-asphalt pavement will be a very good maintenance material for both portland cement concrete and bituminous pavements.

84. The different binder formulations have not been in use long enough to permit conclusive evaluation of their performance. Observation of all the pavements will be continued so that definite recommendations regarding the binder formulations can be made.

85. Climate has a direct effect on epoxy-asphalt pavements. The colder the climate, the greater the tendency for cracking. It is possible that different binder formulations will have to be developed for different climatic areas.

Table 1
Summary of Data on and Observations of Epoxy-Asphalt Pavements Inspected

Field	Location	Date Const.	Binder		De- signed by	Construction		Epoxy-Asphalt Pavement			Remarks
			Type	sq yd		Supv by	Rating	Existing Foundation*	Used for	Performance Rating	
Midwest Area											
Berry Field	Nashville, Tenn.	9/62	II	21,895	Shell	Shell	Good	New AC	Parking	Very good	A few hair-line shrinkage cracks in joints
Wright-Patterson AFB	Dayton, Ohio	10/62	II	2,200	WES	Shell	Fair	PCC T-R over PCC	Parking	Very good	Sawed and filled joints messy
Bunker Hill AFB	Kokomo, Ind.	5/62	III	1,995	WES	WES	Fair	PCC	Parking	Satisfactory	Hairline, circular cracks; reflection cracks
Trux Field	Madison, Wis.	9/62	II	12,100	WES	WES and KCD**	Good	New AC leveling PCC with AC leveling	Parking	Very good	One crack across pavement. Reflection cracks (about 30% underlying joints reflected)
Western Area											
Perrin AFB	Sherman, Texas	9/62	II	10,500	WES	Shell	Poor	AC	Parking and fueling	Unsatisfactory	Pavement condition is result of poor construction and unsatisfactory foundation
Davis-Monthan AFB	Tucson, Ariz.	5/61	I	28,000	Shell	Shell	Fair	AC and PCC	Taxiway	Satisfactory	Pavement in poor condition in areas of base course failure
Los Angeles Int.	Los Angeles, Calif.	7/59	I	3,000	Shell	Shell	Good	AC	Parking and maintenance	Very good	No distress in pavement
George AFB	Victorville, Calif.	10/62	II	11,000	WES	WES	Good	AC and PCC	Runway ends	Satisfactory	Reflection crack and some blistering resulting in loss of tack
Steed AFB	Pano, Nev.	10/62	II	3,400	Shell	Shell	Good	AC	Parking and fueling	Satisfactory	Random shrinkage, and reflection cracks
Pano AFB	Pano, Nev.	8/62	III	10,000	Shell	Shell	Fair	AC	Parking and maintenance	Satisfactory	Random shrinkage cracks
South Atlantic Area											
Homestead AFB	Homestead, Fla.	10/59	I	2,100	Shell	Shell	Fair	T-R pavement	Parking and maintenance	Satisfactory	Blast damage and slight fuel spillage damage. No cracking
Patrick AFB	Cocoa Beach, Fla.	10/61	I	11,000	WES	Corps of Eng	Good	New AC binder	Runway end	Very good	No distress in pavement
Charlotte AFB	Charlotte, N. C.	10/60	I	1,400	Shell	Shell	Good	New AC	Parking and maintenance	Marginal	Random shrinkage cracks (nary 75%)
		10/60	II	1,400						Satisfactory	Random shrinkage cracks (few 25%)
		8/62	II	900						Very good	Minor shrinkage cracks
Seymour Johnson AFB	Goldstoro, N. C.	9/62	II	14,500	WES	WES	Good	PCC and new AC on PCC	Parking and storage	Satisfactory	Reflection cracks occurred in thinner areas of overlay pavement (some reflection cracks filled)
Langley AFB	Hampton, Va.	6/62	II	365	WES	WES	Fair	PCC and new AC on PCC	Parking and fueling	Satisfactory	Heavy fuel spillage but no damage. Minor reflection cracks
Northeast Area											
Hancock Field	Syracuse, N. Y.	8/62	II	5,000	Shell	Shell	Fair	AC	Parking and fueling	Satisfactory	About 15 to 20% of area had poor construction. Hairline cracks in joints and reflection cracks
Bradley Field	Hartford, Conn.	10/59	I	7,000	Shell	Shell	Fair	AC	Runway end	Marginal	Extensive cracking
Burlington Municipal	Burlington Vt.	7/62	II	23,000	Shell	Shell	Good	AC	Parking and maintenance	Satisfactory	One large area in good condition. Three smaller areas show random cracks
Loring AFB	Limestone, Maine	5/61	II	983	Shell	Shell	Fair	AC	Parking and maintenance	Satisfactory	Minor blast damage. Extensive cracking
Westchester Co. Airport	Westchester Co., N. Y.	10/59	I	3,500	Shell	Shell	Poor	AC	Parking and maintenance	Unsatisfactory	Extensive cracking. Extensive construction imperfections

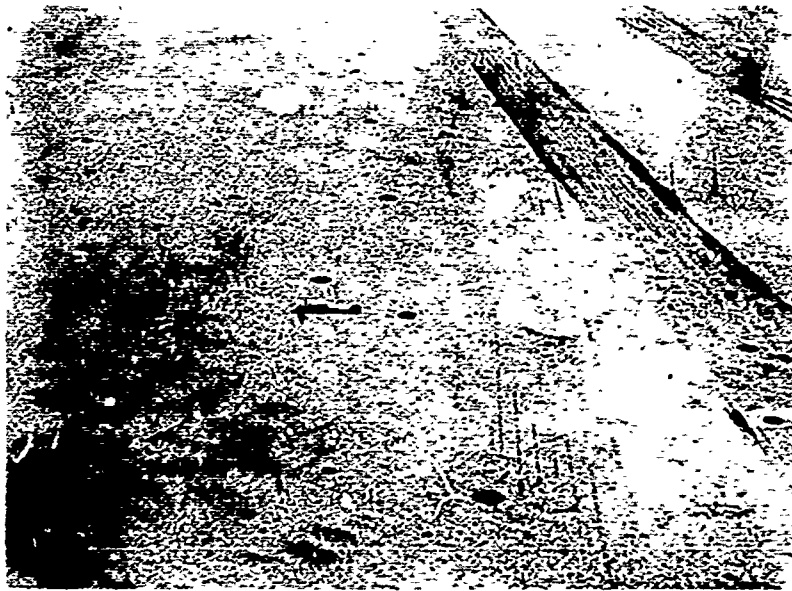
* AC, asphaltic concrete; PCC, portland cement concrete; T-R, tar-rubber concrete.
** SCD, South Central Division, Corps of Engineers.



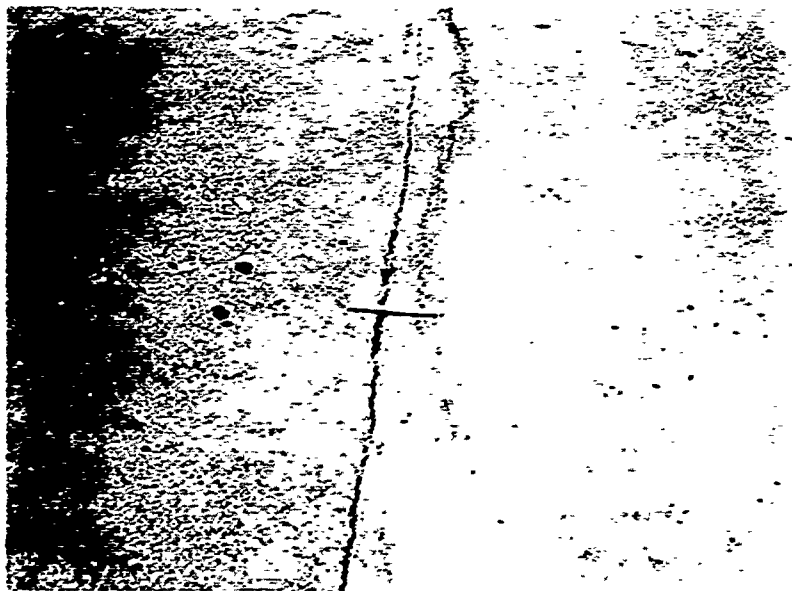
Photograph 1. Berry Field. Edge of overlay pavement. Note proximity of joint in original pavement



Photograph 2. Berry Field. Oil spillage occurring during maintenance operations



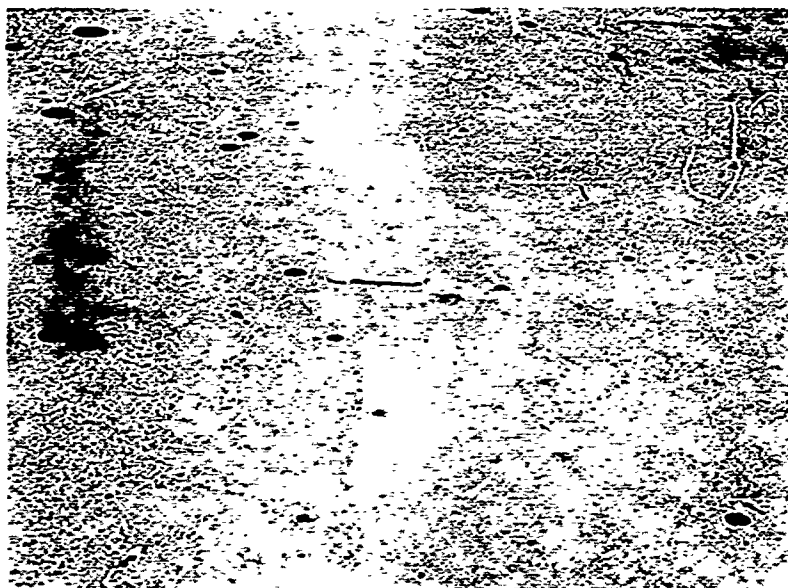
Photograph 3. Berry Field. Surface texture at longitudinal joint in epoxy-asphalt overlay



Photograph 4. Berry Field. Cracked joint in overlay



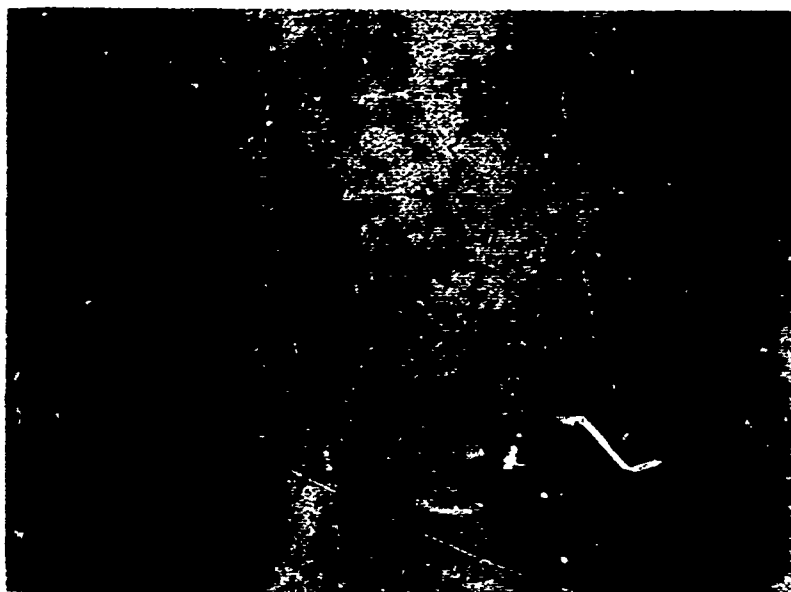
Photograph 5. Wright-Patterson AFB. Overlay at transition from taxiway to apron



Photograph 6. Wright-Patterson AFB. Good surface texture at joint in overlay



Photograph 7. Wright-Patterson AFB. Sealed saw
kerf in overlay at joint in rigid pavement



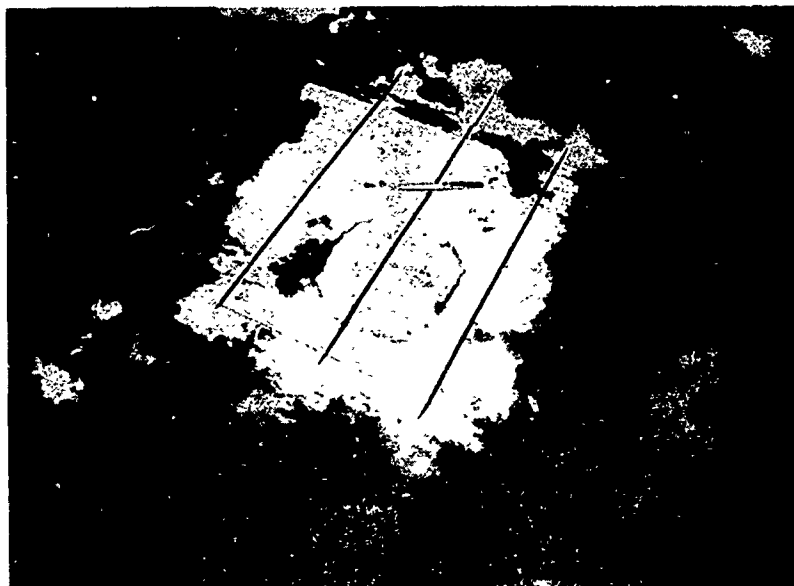
Photograph 8. Wright-Patterson AFB. Reflection
crack in overlay



Photograph 9. Bunker Hill AFB. Overlay on flexible pavement used for parking fuel trucks. Note heavy spillage of fuel and oil



Photograph 10. Bunker Hill AFB. Very small reflection crack in overlay on rigid pavement



Photograph 11. Bunker Hill AFB. Peculiar, circular crack formation in overlay on rigid pavement



Photograph 12. Bunker Hill AFB. Overlay removed, revealing lack of bond within circular cracked area



Photograph 13. Truax Field. Planes parked for maintenance and storage on overlay



Photograph 14. Truax Field. Reflection crack



Photograph 15. Truax Field. Profuse fuel spillage.
Note flow over reflection crack

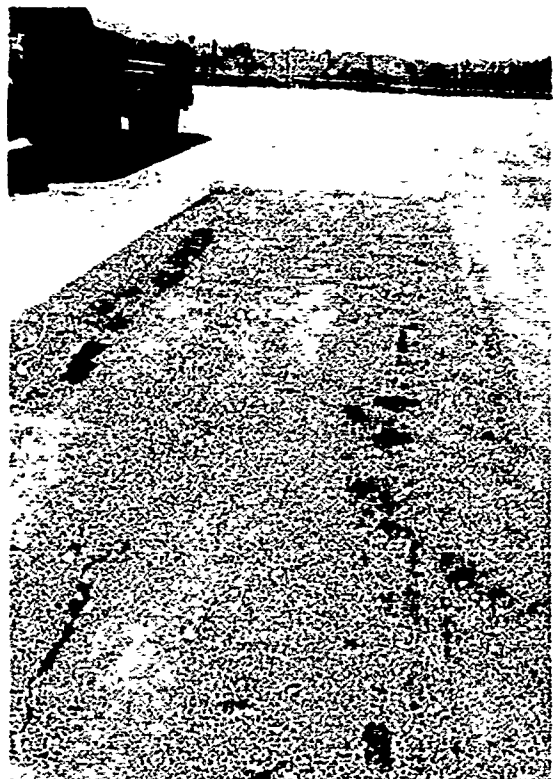


Photograph 16. Truax Field. A hose on fuel tanks
outflow pipe as a precaution against having the fuel
drip on and erode the pavement. Bucket not in place

Photograph 17. Perrin AFB. Edge of epoxy-asphalt overlay showing condition of underlying pavement



Photograph 18. Perrin AFB.
Cracking parallel to paving
lane



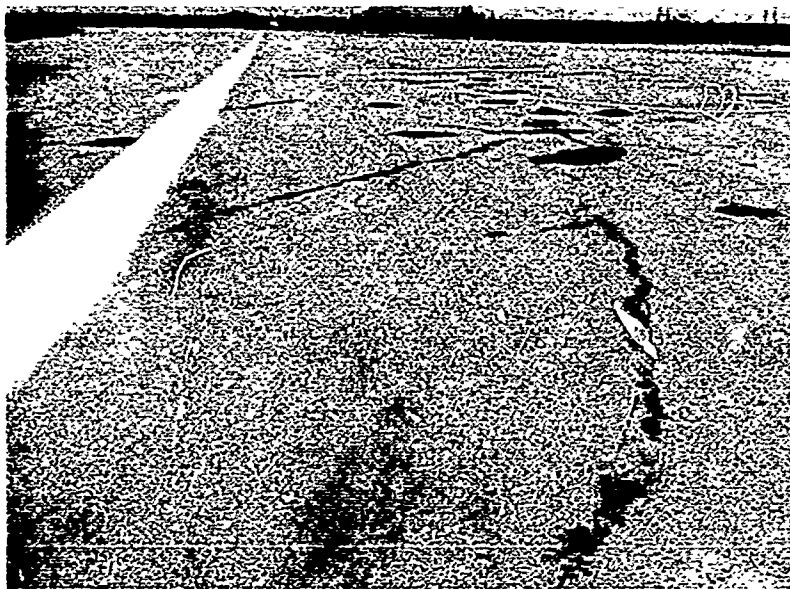
Photograph 19. Perrin AFB. Varied textures of epoxy-asphalt pavement



Photograph 20. Perrin AFB. Large fuel spillage area



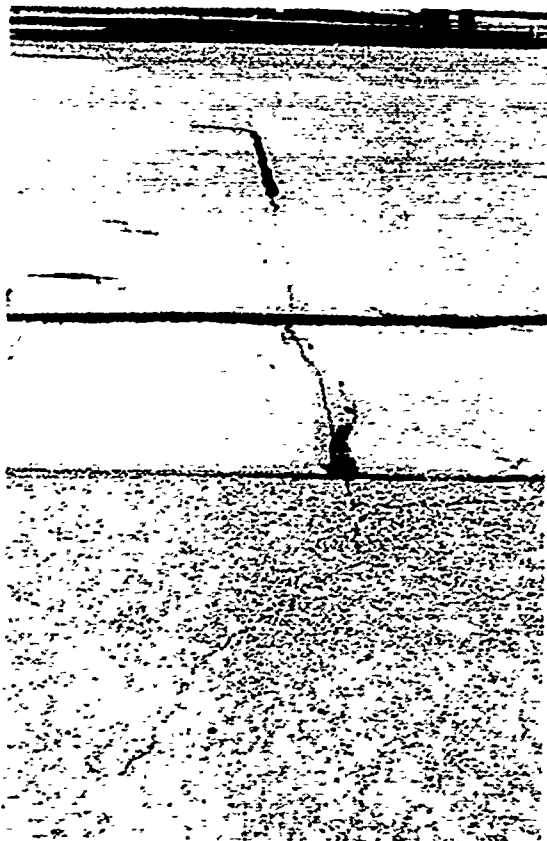
Photograph 21. Perrin AFB. Surface disintegration due to saturated underlying pavement



Photograph 22. Davis-Monthan AFB. Area of epoxy-asphalt overlay with no cracks



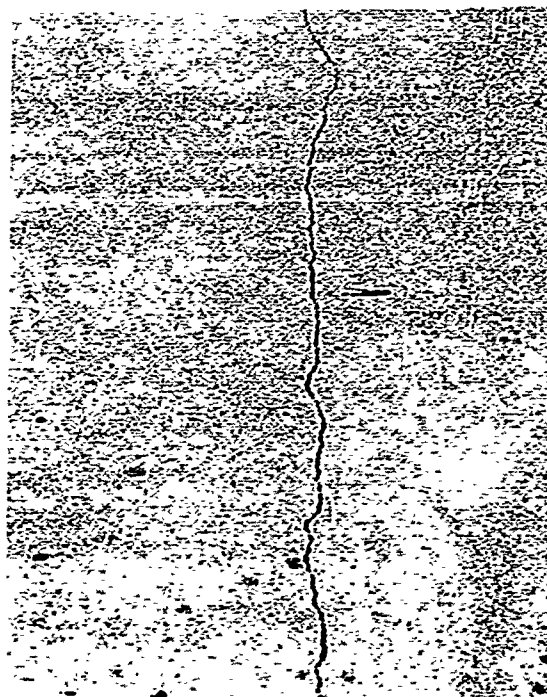
Photograph 23. Davis-Monthan AFB. Unsuccessful attempts to seal cracks in epoxy-asphalt pavement



Photograph 24. Davis-Monthan
AFB. Reflection cracking in
shoulder pavement and epoxy-
asphalt overlay



Photograph 25. Davis-Monthan
AFB. Shrinkage crack in epoxy-
asphalt pavement

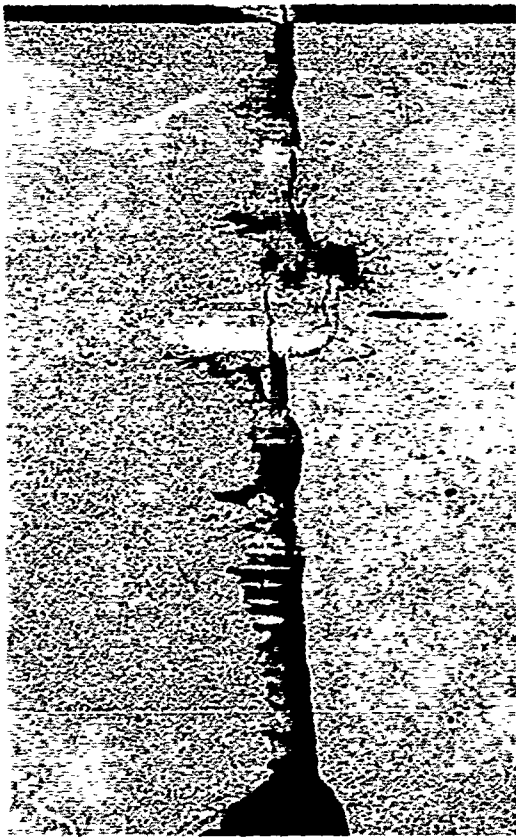




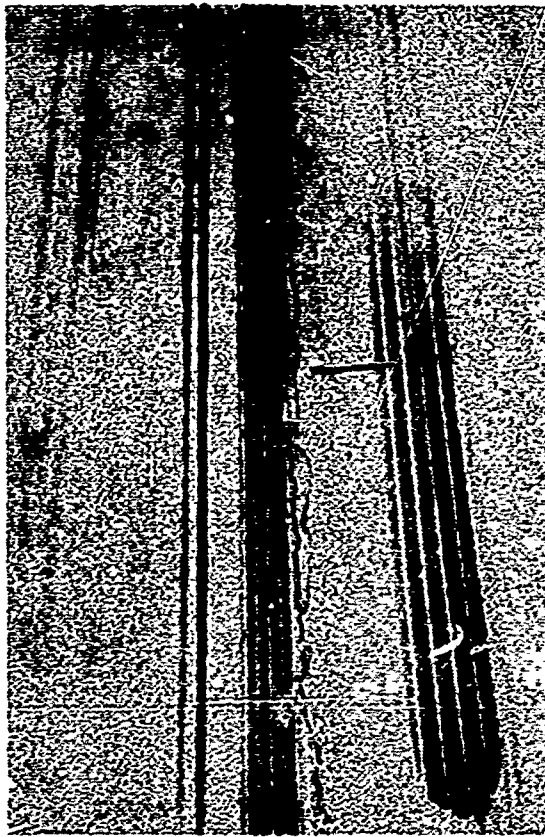
Photograph 26. George AFB. Minor shrinkage and reflection cracking on NE end of runway. Cracks retouched on photograph to make them more visible



Photograph 27. George AFB. Reflection cracks which had been sealed



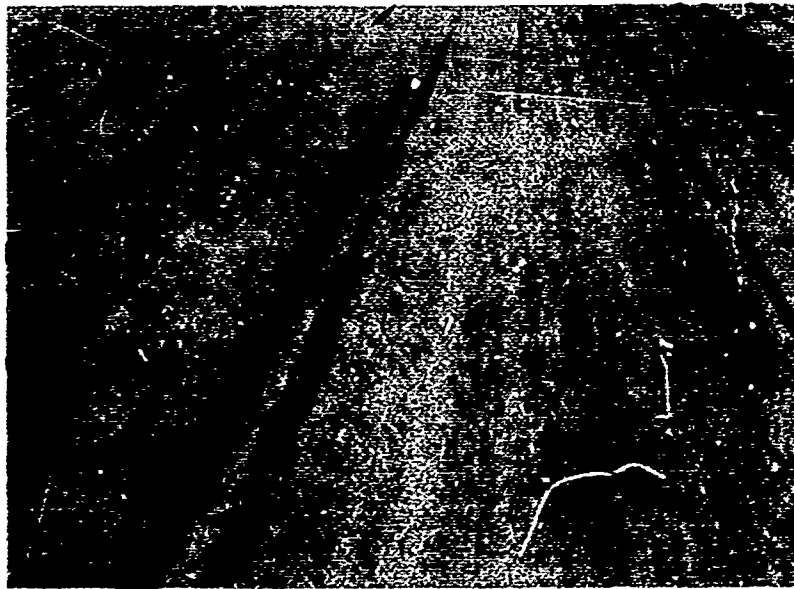
Photograph 28. George AFB. Unsuccessful attempt to fill reflection crack



Photograph 29. George AFB. Reflection cracks on SW end of runway



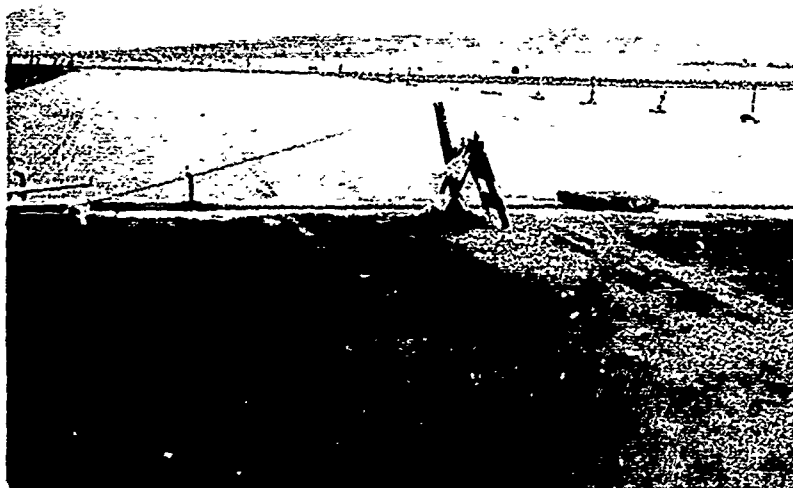
Photograph 30. George AFB. Reflection cracks on SW end of runway



Photograph 31. George AFB. Area of SW end of runway
free of cracks.



Photograph 32. George AFB. Blisters
in pavement containing water

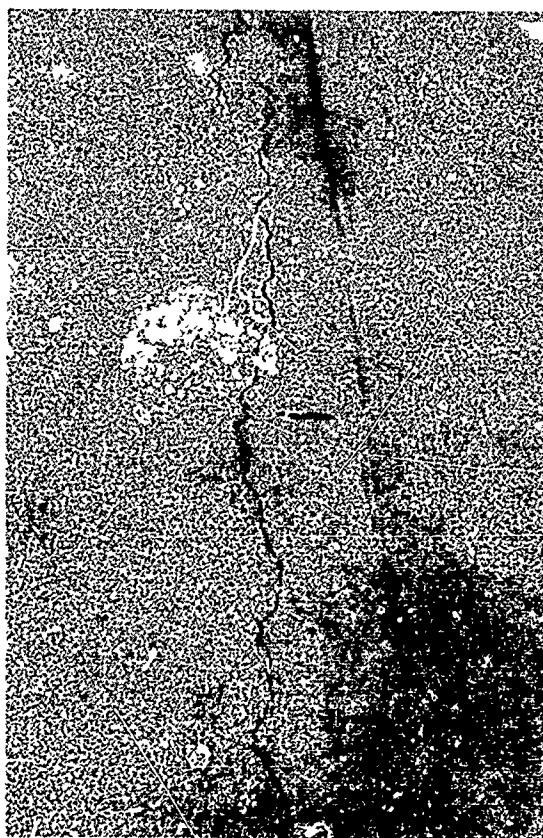


Photograph 33. Stead AFB. General view of epoxy-asphalt overlay for helicopter pad

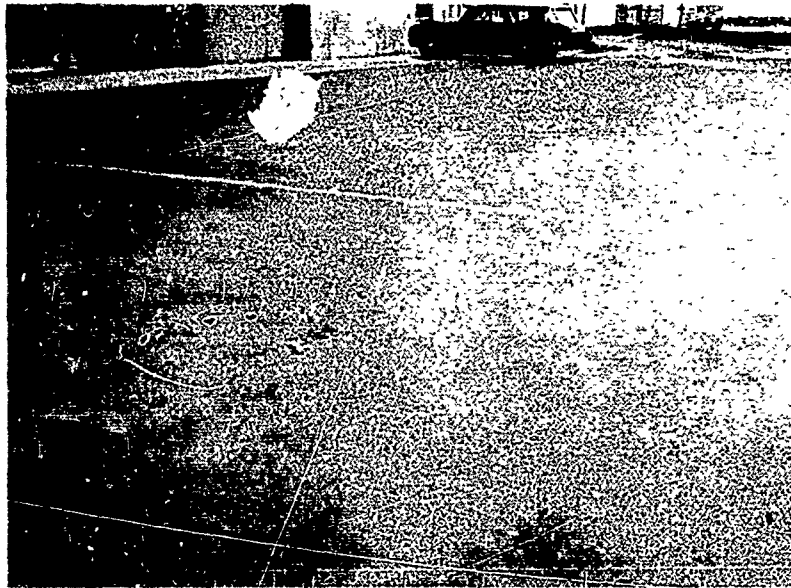


Photograph 34. Stead AFB. Area of epoxy-asphalt overlay free of cracking

Photograph 35. Stead AFB. Reflection cracking in existing pavement and epoxy-asphalt overlay



Photograph 36. Stead AFB. Random shrinkage crack in epoxy-asphalt overlay

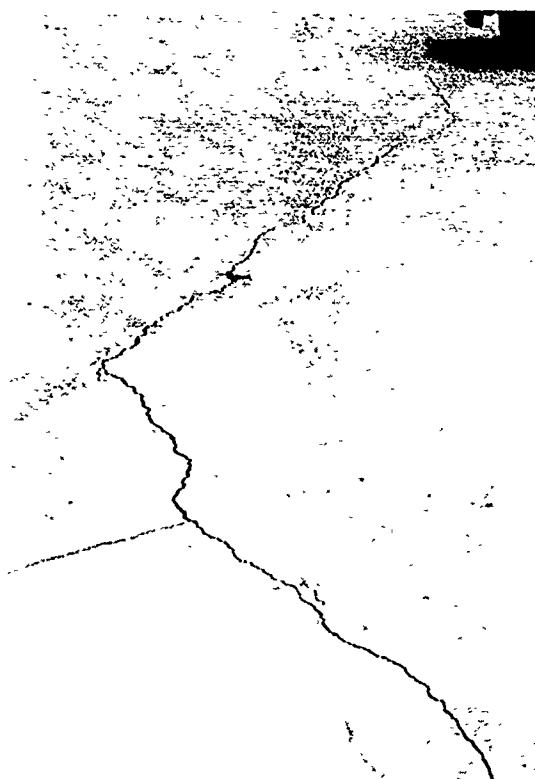


Photograph 37. Reno ANG Field. Epoxy-asphalt overlay in satisfactory condition



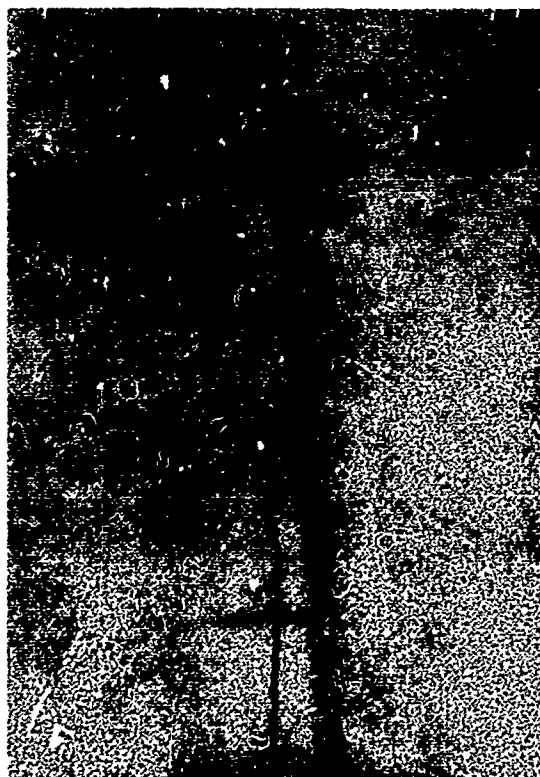
Photograph 38. Reno ANG Field. Close-up of epoxy-asphalt overlay surface

Photograph 39. Reno ANG Field.
Random shrinkage crack. In center
of photograph is fragment of loose
epoxy-asphalt overlay



Photograph 40. Reno ANG Field.
Close-up showing fragment of
pavement broken out of epoxy-
asphalt overlay

Photograph 41. Reno ANG Field.
Random shrinkage crack in epoxy-
asphalt overlay





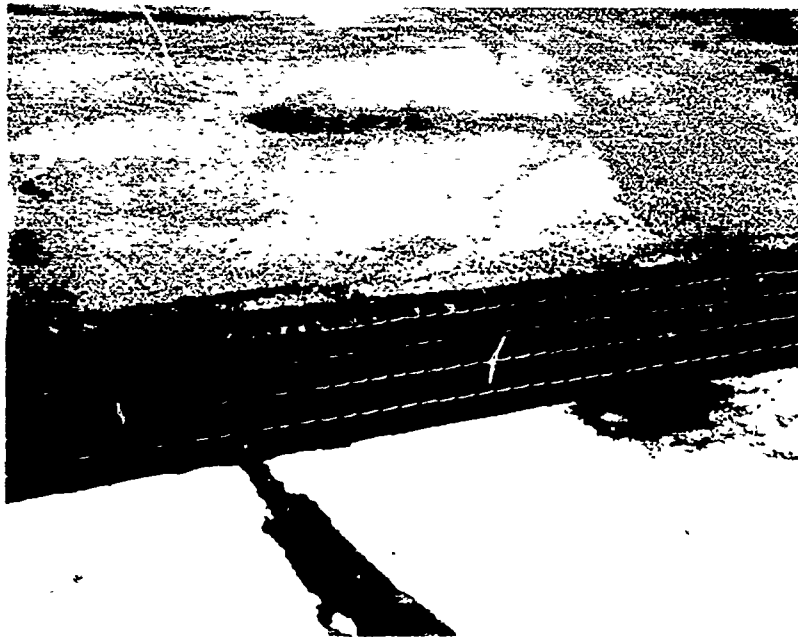
Photograph 42. Seymour Johnson AFB.
Cracks that have been routed and
sealed with epoxy asphalt



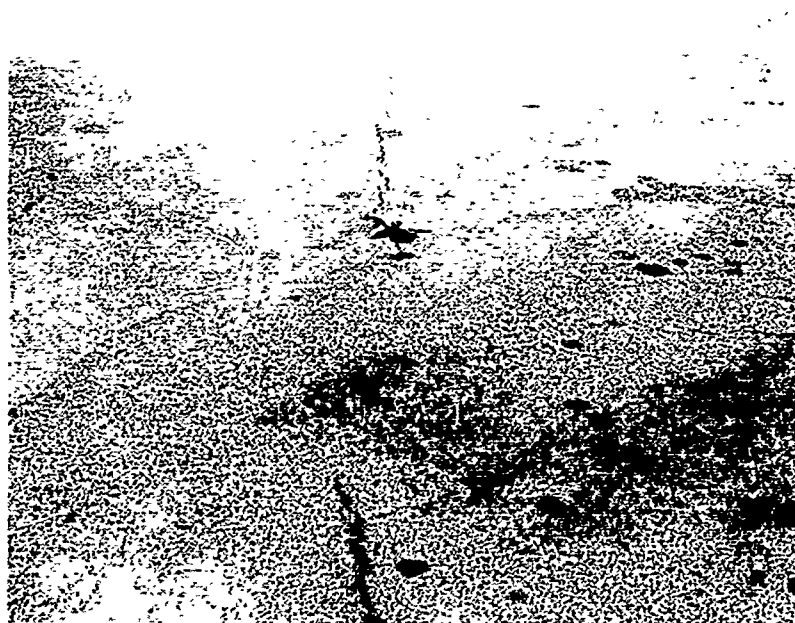
Photograph 43. Seymour Johnson AFB.
Crack sealed with emulsion



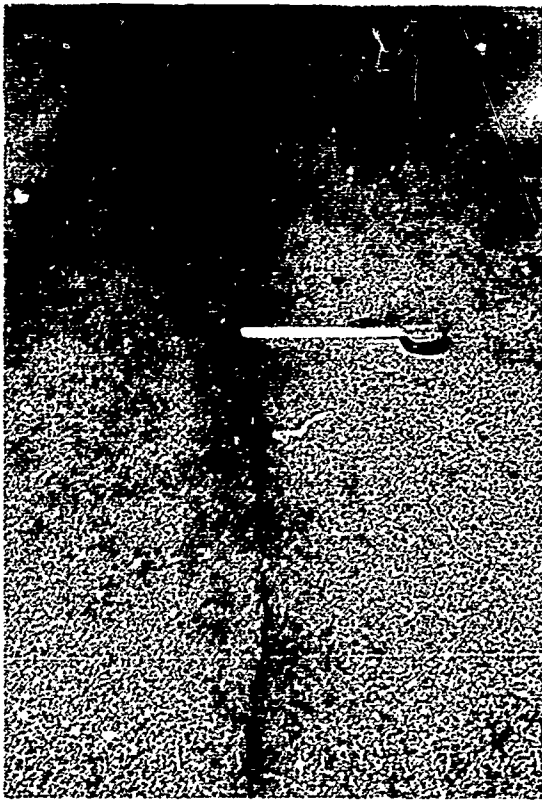
Photograph 44. Seymour Johnson AFB. Cracks in epoxy-
asphalt pavement. Note joint-filling material in
cracks in foreground



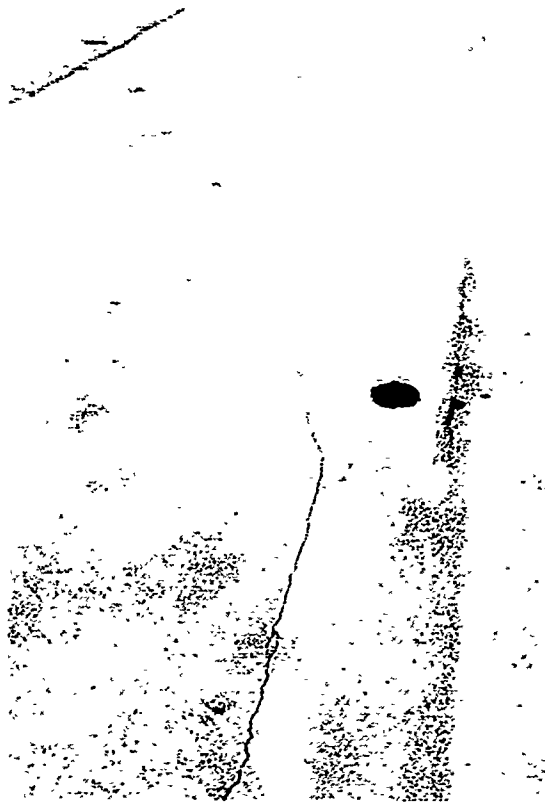
Photograph 45. Langley AFB. Fuel spillage stains on epoxy-asphalt pavement



Photograph 46. Langley AFB. General view of epoxy-asphalt pavement



Photograph 47. Hancock Field. Crack along construction joint in epoxy-asphalt pavement



Photograph 48. Hancock Field. Random crack which parallels a construction joint



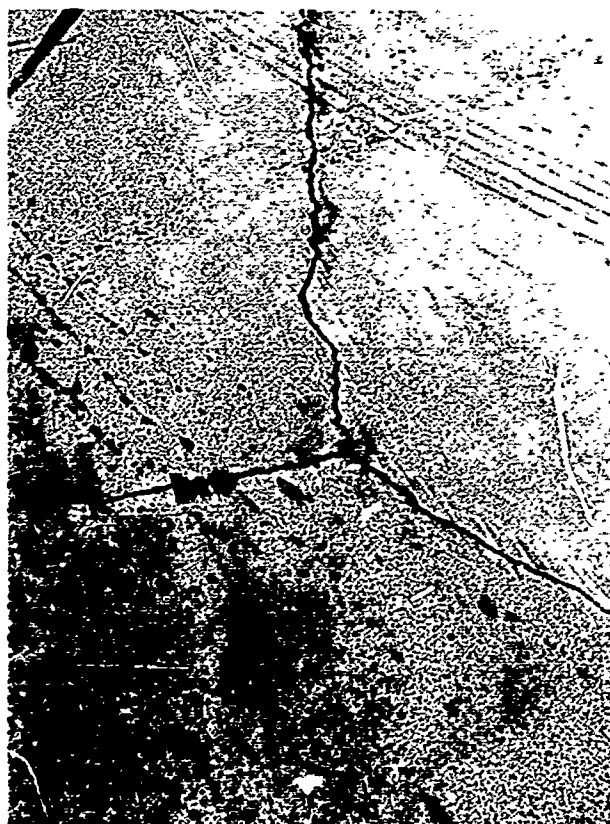
Photograph 49. Hancock Field. Cracks around drop-inlet drain. Cracks retouched on photograph to make them more visible



Photograph 50. Hancock Field. Fuel spillage on epoxy-asphalt pavement.



Photograph 51. Bradley Field. General view of epoxy-asphalt pavement



Photograph 52. Bradley Field. Random cracks beginning to spall in the epoxy-asphalt pavement



Photograph 53. Bradley Field. Transverse crack patterns. The white line is parallel to the center line of the runway



Photograph 54. Bradley Field. Open construction joints in the epoxy-asphalt pavement



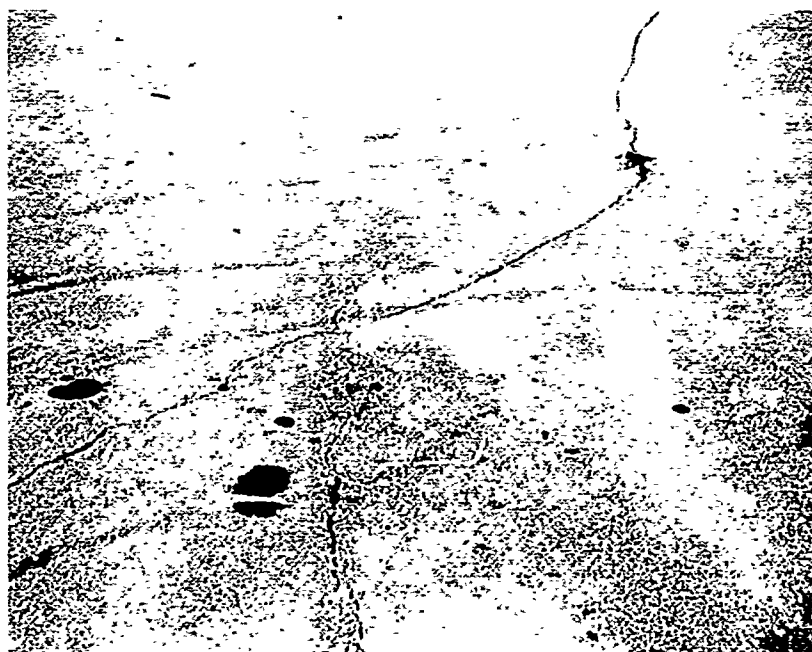
Photograph 55. Burlington Municipal Airport. Large area of epoxy-asphalt pavement with no cracking



Photograph 56. Burlington Municipal Airport. Epoxy-asphalt pavement where little or no cracking has occurred



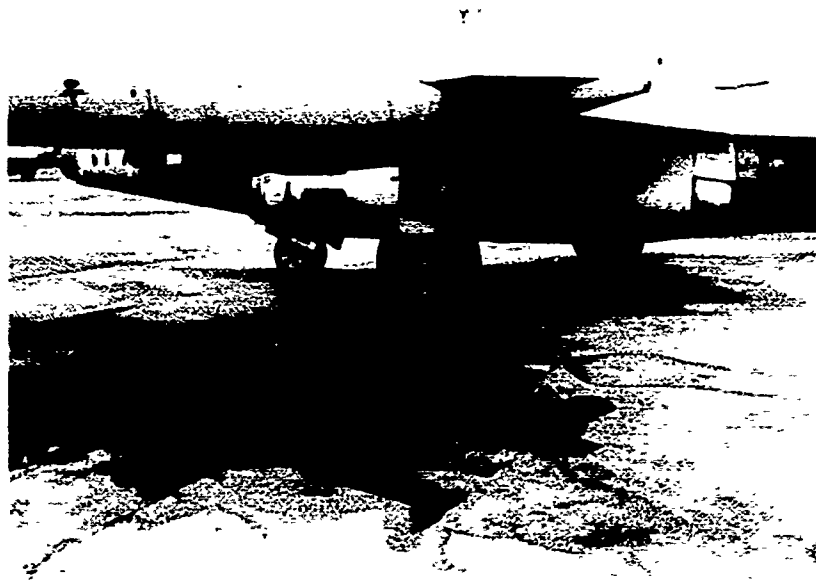
Photograph 57. Burlington Municipal Airport. Typical cracking in epoxy-asphalt pavement



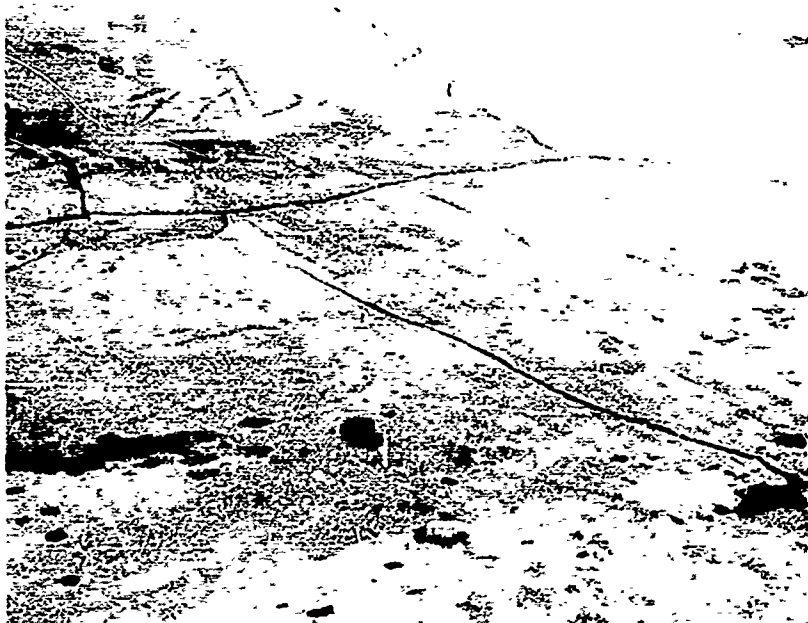
Photograph 58. Burlington Municipal Airport. Random cracks in epoxy-asphalt pavement



Photograph 59. Burlington Municipal Airport. Area where fuel is entering crack between PCC and epoxy-asphalt pavement



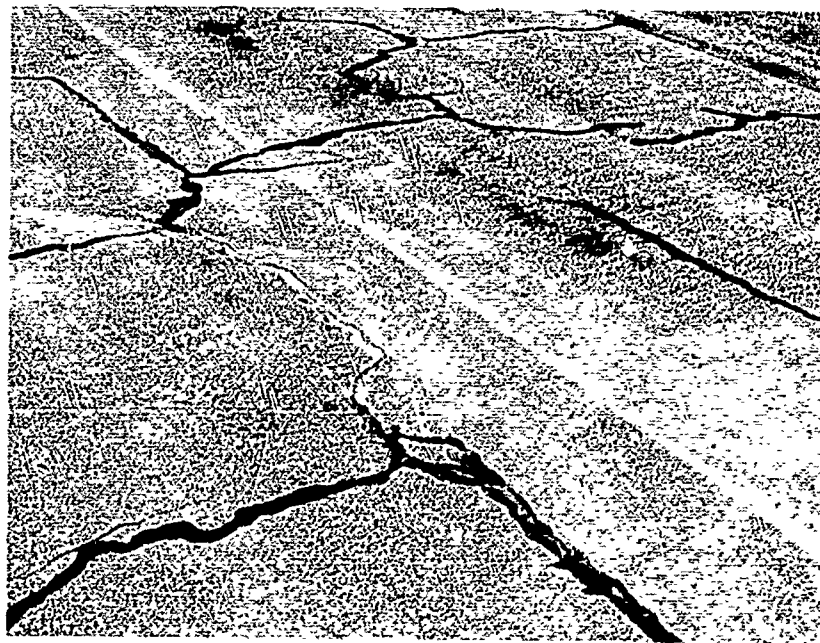
Photograph 60. Burlington Municipal Airport. Fuel spillage from F-89 aircraft



Photograph 61. Loring AFB. Typical cracking on epoxy-asphalt pavement



Photograph 62. Loring AFB. Area where outboard engine of a B-52 had blown away a small portion of epoxy-asphalt pavement



Photograph 63. Westchester County Airport. Typical cracking in epoxy-asphalt pavement



Photograph 64. Westchester County Airport. Cracking pattern on epoxy-asphalt pavements with patches in background